# Pedagogical knowledge towards argumentation in science classroom

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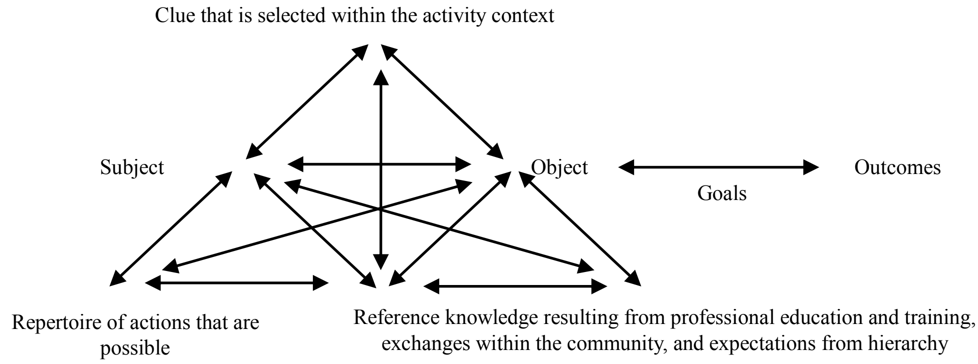
Science teachers are increasingly expected to use inquiry based science teaching [IBST] methods. According to the S-TEAM and ASSIST-ME European projects, IBST methods lead students to understand key scientific ideas that help them to make sense of the phenomena in the world around. Students are supported in using process and skills employed by scientists: questioning, reasoning, searching for relevant documents, observing, conjecturing, data gathering and interpreting, investigative practical work and collaborative discussions, and working with problems from and applicable to real-life contexts.

This is a complex combination of objectives. This complexity claims for a better understanding of the set of teacher professional knowledge that is required by IBST methods. This presentation addresses the ways for identifying this type of knowledge and for understanding its development.

### The Development of Professional Knowledge

Professional knowledge is understood as a synthesis among what had been learnt through both professional education, individual experience and collective interactions within the work setting (Fisher & Boreham, 2004; Grangeat & Gray, 2007, 2008). Such a professional knowledge consists of four elements (Grangeat & Gray, 2007; Grangeat, 2013): *goals* which orientate the actors' activity; *clues* which are elements of the work situation identified and selected by actors and which trigger a particular type of action; *repertoire of actions* which generate and monitor the actions according to the specific goal and object of the activity; *reference knowledge* which underlines and justifies the actual actions (see Figure 1).

Figure 1: Elements of professional knowledge




This knowledge is developing through experience and collective interactions. This development consists of progressive and repeated reorganizations of ways of reflecting about professional activities and of acting effectively. It occurs when agents need to alter their approaches or methods in order to carry their tasks out more efficiently.

Such an evolution is frequently spread between two poles (Hudson, 2007).The first pole is centered on the fundamental aspects of the activity. The second pole enlarges the field of professional knowledge: teachers maintain a balance between subject requirements, students' characteristics, and some colleagues' activities. These two poles are not exclusive and professional knowledge actualization varies according both to teachers' commitment, experience or training, and to the specificity of the teaching situation resulting, for instance of the pupils' social characteristics or the school's organization (Grangeat & Gray, 2007).

Within complex situations in which actors cannot directly control all the factors that interact on their activity outcomes, professional knowledge are networked upon the main dimensions of the activity. Six main dimensions underpin IBST: origin of questioning; nature of problem; students' level of responsibility; awareness of students' diversity; development of argumentation; teacher's goal explanations (Grangeat, 2013). This study focuses on « development of argumentation »

### The teachers' professional knowledge

Teaching is a professional activity that does not consist merely of transferring specific scientific content from teachers to students. This is a complex activity that necessitates specific knowledge. For this reason, over the past decades, a lot of research have endeavored to better understand the nature and the development of teachers' knowledge (Alonzo, Kobarg, & Seidel, 2012; van Driel, Verloop, & de Vos, 1998). This research area is connected to Shulman's ideas that distinguish three interconnected types of knowledge: subject matter knowledge (SMK), pedagogical content knowledge (PCK), and general pedagogical knowledge and skill (GenPK). This presentation only addresses the linkage between PCK and GenPK.

PCK is both topic-specific and context-dependent and results from a combination of familiarity towards a specific topic with reflection on teaching experience. GenPK complements knowledge linked to a specific content, but very few researchers have tackled this question. Some research only considers GenPK as part of a wide teacher professional knowledge base (Gess-Newsome & Lederman, 2001)others merely explore declarative GenPK through tests (König, Blömeke, Paine, Schmidt, & Hsieh, 2011).

**Research question**

Teacher professional knowledge combines diverse types of knowledge that are drawn from diverse sources, as it is the case for other professionals facing complex and collective activities. This knowledge may be organized upon three interconnected categories regarding to subject matter (SMK), general pedagogy (GenPK) and specific content pedagogy (PCK). The point is to understand the linkage and interaction among these three types of knowledge; this presentation will only focus on the linkage between the two last ones.

Two research questions have to be answered. Over the past decades, PCK had been described more and more specifically but GenPK left unexplored. The first question consists in describing this general pedagogical knowledge and in distinguishing it from PCK. The second question consists in exploring the repartition of these two categories in science teachers' approaches and practices: Is one of these two prevalent? For what type of teachers? The responses may lead to orientate teacher education and training.

The study will focus on teacher professional knowledge toward argumentation in IBST methods. It will compare new science teachers (NST) with experienced teachers (EST) and science teachers who are committed in their colleagues' in-service training (CST).

**Methodology: Identifying Teacher Professional Knowledge for IBST**

The sample consists of eighteen science teachers (eight males, ten females) split into three groups. They were teachers of mathematics, biology and earth or physics and chemistry in lower secondary schools in France.

The first group comprised six committed science teachers [CST] who frequently met together and with inspectors in order to design and carry out CPD programs for other science teachers. The second comprised six new science teachers [NST]. During their first teaching year, they attended five specific CPD sessions, which emphasized specific teacher collaboration based on discussion and exchange about IBST topics and five sessions about specific content that may be included in IBST lessons (Grangeat & Leroy, 2010). The third comprised six experienced science teachers [EST] who were neither involved within professional networks nor CPD programs about IBST.

**Expected Findings**

The comparison amongst the three groups of teachers may result in two alternative patterns. The results may depend either on teachers' experience or commitment. The first pattern is drawn on teachers' experience: the more the teachers have had the opportunity to reflect on their practice as science teachers the more their knowledge are specific. Thus, the results' pattern might be: NSTs demonstrate more GenPK than PCK, ESTs are in an intermediary position, and CSTs demonstrate the PCK maximum. The second pattern is drawn on teachers' commitment: the more the teachers have had the opportunity to exchange and debate with colleagues about science teaching methods the more their knowledge are specific. Thus, the results' pattern would be: ESTs demonstrate more GenPK than PCK, NSTs are in an intermediary position, and CSTs again demonstrate the PCK maximum.

**Results: the importance of teachers' pre and in-service education**

Two analyses are conducted. The first consists in describing what general pedagogical knowledge is and in distinguishing it from PCK. The second consists in exploring the repartition of these two categories in science teachers' approaches and practices of the sample and to test the relevancy of the two above patterns.

**Distinguishing GenPK from PCK**

The content and video analysis interview and lesson of each teacher leads to elaborate constructs that are conceived as STPK. These constructs consist of goals and sub-goals, clues, actions and justifications. This results in two types of STPK: GenPK and PCK.

Some STPK refers to general pedagogical methods that can be applied by diverse teachers, whatever their discipline is. This type of professional knowledge addresses the classroom management in order to meet the teacher's objectives. Thus, it is a pedagogical knowledge. On the other hand, this knowledge is not specific to a type of subject, since any teacher can apply this kind of knowledge. Thus it is a general pedagogical knowledge (GenPK). A second type of STPK is referred to a specific content that distinguish teachers from diverse subjects. It addresses the way teachers may manage the classroom in order to make understood a notion or method that is specific to a disciplinary notion. In this sense it represents PCK. To sum up, GenPK and PCK are similar regarding the nature of their constitutive elements but different regarding the object of the teacher activity of three of these elements (see Table 1).

Table 1: Distinction between general pedagogical knowledge and pedagogical content knowledge

| STPK elements | GenPK | PCK |
|---|---|---|
| Goals | To achieve key competences | To achieve key competences |
| Clue | Classroom management: f.i. accurate proceedings of all the pupils' teams; adaptation of the task for some specific learners. | Understanding of specific subject notions: f.i. using of appropriate vocabulary or problem solving method. |
| Repertoire of actions | Actions that are similar for all teachers (f.i. supervising all the pupils' teams) or within a large subject domain (f.i. using graphical representations). | Actions that are specific to a notion and that tackle the learners' difficulty towards this notion (f.i. $6^{th}$ grade learners cannot easily identify all the diagonals of a polygon with numerous sides.) |
| Reference knowledge | Referred to crosscutting competences (f.i. motivation, self-regulation, formative climate, etc.) | Referred to domain specific competences (f.i. nature of science, specific scientific inquiry methods, etc.) |

The analysis of the videos and interviews of the 18 teachers regarding the dimension 'argumentation' of IBST leads to identify 73 STPK including 59 GenPK and 14 PCK. Thus in the sample, more than 80% of the STPK are general. This first results lead to a second analysis aiming to elicit the repartition of these set of professional knowledge regarding the types of teachers.

**Repartition of STPK regarding the teachers' types**

The set of PCK is not equally distributed among the teachers' sample. The results doesn't correspond to any expected pattern. New teachers report PCK more frequently than teachers who benefit from more experience. Teachers who are not involved in collective settings don't report any PCK (see Table 2).

Table 2: Repartition of general pedagogical knowledge and pedagogical content knowledge

| | GenPK | PCK | | |
|---|---|---|---|---|
| EST [N=6] | 20 | 0 | **20** | 27% |
| CST [N=6] | 23 | 3 | **26** | 36% |
| NST [N=6] | 16 | 11 | **27** | 37% |
| | **59** | **14** | **73** | |
| | 81% | 19% | | |

The balance between GenPK and PCK is modified regarding the teachers' types. Within this sample, NSTs report an expected repartition (60% vs 40%).

New teachers report most of PCK. They had benefited of a specific program of teacher education that had been designed and carried out by a team of teacher educators including pedagogues and didacticians (subject specialists). The analysis shows that these new teachers had adapted the approaches, practices and methods that had been discussed during this education program.

At the opposite, isolated teachers (ESTs) report TPK that rely only on very general repertoire of actions and justification. They seem to not focus on the specific scientific knowledge elaboration by their students. They report very vague crosscutting competencies and the video analysis demonstrate that their IBST methods are far to be efficient: for instance, they never help their students to summarize what had been learned during the lesson.

Surprisingly, the situation is quite similar for the teachers involved in a group in charge of designing and carrying out CPD programs for their colleagues. Their professional activity might be underlined by a poor connection between cross-cutting and specific competences.

Consequently, we think that GenPK and PCK need to be handled together by pre and in service teacher education in order to allow students and pre-service teachers to elaborate in parallel these sets of professional knowledge. This result is coherent with those of Nilsson and van Driel (2010) who showed how pre-service teachers and their mentors can elaborate both general and content pedagogical knowledge. In any case, further studies need to be designed in order to explore the connection between these two fundamental types of teacher professional knowledge.

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